THE ORDOVICIAN TRILOBITE FAUNAS OF SOUTH SHROPSHIRE, IV

BY

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SYNOPSIS

The trinucleid genus *Broeggerolithus* is recorded and figured from the Actonian Stage, and the specimens assigned to *B. transiens* (Bancroft). Specimens of *Tretaspis* are figured for the first time from Shropshire and described as *T. ceriodes* (Angelin) *favus* subsp. nov. The distribution and relationships of all the known Caradoc trilobites in south Shropshire are discussed.

I. INTRODUCTION

This publication forms the fourth and final part of a series of bulletins covering the Ordovician (Caradoc) trilobites of south Shropshire. The first three parts contained descriptions of all the families of trilobites known in the district, and it was intended that the present paper should include subsequent discoveries, as well as summarizing our knowledge of the Caradoc trilobites in England and parts of Wales. In addition to my later collecting, the extensive material obtained during the Geological Survey's re-mapping of the Church Stretton One-inch Sheet 166 has been generously placed at my disposal, and I am indebted to Dr. F. W. Anderson and Mr. J. D. D. Smith for their co-operation. Although some new fossiliferous localities have resulted from this survey, no species has been discovered which had not previously been collected from other localities. None of the specimens has been found to necessitate a departure from the scheme of stages and zones with their associated shelly faunas propounded by the late B. B. Bancroft, whose remarkable researches received so little recognition thirty years ago. Present-day knowledge of the detailed equating of the graptolite with the trilobite/brachiopod zones still leaves much to be desired, and the whole question of Caradoc correlation is beset with difficulties resulting from the constantly changing pattern of the boundaries of faunal provinces and facies, now known to have been far more complex than was at one time realized. Nevertheless, the basic framework of Bancroft's stages seems to afford the obvious approach to problems of Middle and Upper Ordovician correlation, and has already proved highly promising in northern England, North Wales, parts of South Wales, and areas of Shropshire to the west of the type Caradoc district. I am indebted to Professor W. F. Whittard who, as so often before, has read the manuscript and offered much useful advice.

II. SYSTEMATIC DESCRIPTIONS

Family TRINUCLEIDAE Hawle & Corda 1847

Subfamily CRYPTOLITHINAE Angelin 1854

Genus *BROEGGEROLITHUS* Lamont 1935

TYPE SPECIES. *Cryptolithus broeggeri* Bancroft by original designation of Lamont (1935 : 320).

Broeggerolithus nicholsoni (Reed)

1910. *Trinucleus nicholsoni* Reed : 212, pl. 16, figs. 1–9.
1962. *Broeggerolithus nicholsoni* (Reed) Dean : 79. Includes full synonymy.

The species was described from strata which Reed believed to be Dufton Shales near the village of Melmerby, Cumberland. The rocks, to which the name Melmerby Beds has since been applied, form part of the complex Cross Fell Inlier and are known to be of Longvillian age. Although most of the specimens from Melmerby, including practically all the original syntypes, derive from what are thought to be Lower Longvillian beds, the species ranges upwards into the early part of the Upper Longvillian, and has recently been redescribed (Dean 1962 : 79).

In an earlier paper (Dean 1959 : 120), before *B. nicholsoni* was adequately known, *Broeggerolithus simplex* was described from the Lower Longvillian Substage of the Onny Valley. More recently it has been suggested that the two species are synonymous (Dean 1962 : 81), and *B. nicholsoni* has been confirmed at the following localities in south Shropshire, all comprising rocks of Lower Longvillian age. *a.* Various exposures in Rookery Wood, east of Horderley ; *b.* the small quarry in Longville Plantation, 740 yards north-west of the Earthwork at Cheney Longville ; *c.* Long Lane Quarry, two-thirds of a mile south-west of Cheney Longville ; *d.* the large roadside quarry 280 yards south-east of Glenburrell Farm, Horderley ; *e.* the cutting just east of Chatwall Farm, four and a half miles north-east of Church Stretton, though the evidence here is somewhat fragmentary. Localities *a.*, *b.* and probably *e.* are in the zone of *Dalmanella indica* and *D. lepta* ; *c.* and *d.* are in the zone of *Dalmanella horderleyensis*.

The contemporaneous *Broeggerolithus globiceps* is undoubtedly closely related to *B. nicholsoni* and possibly represents no more than a variety. The same may also be said of *Broeggerolithus longiceps*, though the latter is stratigraphically later in south Shropshire.

Broeggerolithus transiens (Bancroft)
(Pl. 1, figs. 1–4)

1929. *Cryptolithus transiens* Bancroft : 90, pl. 2, fig. 5.
1960. *Broeggerolithus transiens* (Bancroft) Dean : 123, pl. 18, figs. 2, 3, 7, 8, 11–14. Includes full synonymy of the species.

During earlier field-work in south Shropshire no reliable evidence of trinucleid trilobites was obtained from the strata of Actonian age, though one fragment of cephalic fringe, doubtfully assignable to *Broeggerolithus*, was collected from weathered Actonian sandstones at Acton Scott. More recently specimens of *Tretaspis* were found in the grey mudstone facies of the Actonian, and the collectors of the Geological Survey have recovered fragments of *Broeggerolithus* from the arenaceous facies as exposed in the old quarry 1,400 feet west-north-west of St. Margaret's Church, Acton Scott. The best-preserved of these is the internal mould of a damaged cranidium, approximately 17 mm. broad, which exhibits all the essential characteristics of *Broeggerolithus transiens*. The pit count for the four outer rows of fringe pits is estimated as follows : $E_1 + e_1 = 22$, $E_2 + e_2 = 22$, $I_1 + i_1 = 20$, $I_2 + i_2 = 21$. These figures fall within the range of variation of the species as established for specimens of Marshbrookian age (Dean 1960 : 124). The discovery of what is typically a Marshbrookian species, even though rarely, in Actonian rocks is interesting but does not affect the concept of the boundary between the Marshbrookian and Actonian Stages in south Shropshire. The base of the Actonian is well marked by the incoming of new faunal elements, and does not rely on the occasional upward extension of older species groups.

Subfamily TRETASPIDINAE Whittington 1941

Genus ***TRETASPIS*** M'Coy 1849

Type species. *Asaphus seticornis* Hisinger by subsequent designation of Bassler (1915 : 1285).

Tretaspis ceriodes (Angelin) ***favus*** subsp. nov.
(Pl. 1, figs. 5–7 ; Pl. 2, figs. 1–6)

Diagnosis. *Tretaspis* with five concentric rows of fringe pits, E_1 and I_{1-4}, developed frontally. An additional row, E_2, developed laterally, from about R9. Approximately 22 pits in E_1. Rows I_3 and I_4 discrete frontally but conjunct posterolaterally, at or near R18. Pygidium with five axial rings, the first four extending posterolaterally to form pleural ridges on side-lobes.

Description. The entire dorsal exoskeleton has not yet been found, and the subspecies is known mainly from disarticulated cranidia and rare pygidia. The cranidium is strongly convex dorsally, approximately twice as broad as long, and generally rounded in plan, though with a suggestion of angulation both frontally and anterolaterally (see Pl. 2, figs. 1, 5). The glabella is clavate in plan, with maximum breadth three-quarters of the length, and occupies about seven-eighths of the projected length of the cranidium owing to the steep declination of the cephalic fringe frontally (see Pl. 2, fig. 5). The frontal glabellar lobe, in length about two-thirds that of the glabella, is swollen, subhemispherical, stands high above the cheek-lobes (see Pl. 2, fig. 3), and extends well in front of the latter so as to invade the area of the pitted cephalic fringe, the concentric rows of which are curved forwards medially to accommodate the glabella. The pedunculate posterior portion of the glabella is narrow, about one-third the breadth of the frontal glabellar lobe, and expands backwards to form a basal ring which is half as broad (*tr.*) as the frontal glabellar lobe. There are three pairs of glabellar furrows. Those of the first, or anterior, pair are conspicuously smaller than the others and occur only as small, almost transverse notches, indenting the sides of the glabella just behind centre. The second glabellar furrows comprise a pair of deep, reniform depressions midway between the first pair of furrows and the occipital furrow, strongly divergent forwards and placed high on the sides of the glabella at the junction of the frontal glabellar lobe and peduncle, so that they do not cut the axial furrows. The third, or basal, glabellar furrows are slightly smaller than those of the second pair, more slot-like in form, and diverge backwards strongly so as to intersect the axial furrows. As a result of the position of the glabellar furrows, what would normally be the first and second glabellar lobes are conjunct distally and merge into the proximal sides of the axial furrows. The cheek-lobes are quadrant-shaped, plump, each surmounted by a conspicuous lateral ocellus at its apex. The axial furrows are slightly divergent forwards, almost straight, deepest frontally where they contain a pair of hypostomal pits but broadening markedly towards the occipital furrow. The occipital ring is fairly large, moderately inclined backwards with maximum length at the sagittal line, separated from the glabella by a broad (*sag.*), shallow occipital furrow which deepens distally into a pair of conspicuous occipital pits, denoting a pair of apodemes.

The posterior margin of the cephalon is indented slightly at the outer ends of the occipital ring, in line with the axial furrows. In the pleuroccipital furrow a large pit is situated at each fulcrum, just inwards from the posterolateral angle of each cheek-lobe (see Pl. 1, fig. 5). These pits, although sited immediately adjacent to the innermost corners of the cephalic fringe, nevertheless appear to be distinct from that structure, and have been termed " lateral pits " by Stäuble (1953 : 91). They are considerably larger than the neighbouring fringe pits, which become progressively smaller proximally, and their function is not yet clear though the apodemes corresponding to them on the ventral surface of the test are probably concerned with the attachment of the first thoracic segment to the cephalon. They have not yet been detected in any of the other Shropshire trinucleids all of which, however, belong to a different subfamily, the Cryptolithinae. From the axial furrows as far as the fulcral pits the posterior margin of the cephalon is both transversely straight and horizontal, but then turns down and sweeps backwards to the genal angles. The latter are marked by a pair of librigenal spines of typical trinucleid form which have not yet been found completely preserved.

The greater part of the surface of the glabellar test is covered with thin, raised, anastomosing ridges which form a reticulate pattern, the superficial resemblance of which to a honey-comb gives the subspecies its name. The reticulation is coarsest over the upper half of the frontal glabellar lobe and along the dorsal part of the " peduncle " but becomes both finer and less well defined towards the axial furrows. It dies out before reaching the axial furrows, leaving a smooth band which circumscribes the anterior margin of the frontal glabellar lobe (see Pl. 2, fig. 3) and continues backwards to the occipital furrow, at the same time encompassing the area occupied by the three pairs of glabellar furrows (see Pl. 2, fig. 6). The apex of the glabella, sited approximately at the mid-point of the frontal glabellar lobe, is topped by a small but conspicuous median ocellus. The latter scarcely protrudes above the outer surface of the test but appears larger on internal cephalic moulds. This indicates that the median ocellus involves a thinning of the test, a feature demonstrated by Størmer (1930, pl. 13, figs. 3, 5, 6) for various Norwegian species of *Tretaspis*. The reticulation immediately surrounding the median ocellus shows a suggestion of concentric arrangement proximally, but this quickly becomes obliterated distally. Likewise, there is a tendency for the reticulation to form a parallel pattern along a faint ridge developed between the median ocellus and the occiput, but both ridge and pattern quickly die out forwards.

The external surface of each cheek-lobe is covered with reticulate ridges similar to those on the glabella. The reticulation is generally coarsest on the proximal half of each cheek-lobe, but anteriorly and, more particularly, laterally it becomes finer and finally dies away, so that a smooth strip of test separates the cheek-lobe from the cephalic fringe. All the reticulation is developed only weakly on internal moulds. Each cheek-lobe carries a large, apically sited, lateral ocellus just behind centre, a position coinciding generally with the line of change from coarse to fine reticulation. There is a poorly-developed ocular ridge running forwards and adaxially from each lateral ocellus until it terminates at the axial furrow opposite the first glabellar furrows. The remainder of the cephalic test, like that of the thoracic segments and pygidium, is smooth.

The cephalic fringe is steeply declined frontally, becoming less so posterolaterally, where it is produced to form genal prolongations which extend behind the line of the pleuroccipital segment for a distance equal to a little less than one-third of the median length of the cephalon. Anteriorly the fringe is of almost uniform breadth (*exsag.*) as far as the anterolateral angles, beyond which it expands towards the genal angles. The holotype, the best-preserved specimen, shows five continuous rows of fringe-pits frontally, namely E_1 and I_{1-4}. The outermost three rows of these are transversely straight at this point, but the two innermost rows are flexed forwards a little so as to accommodate the frontal glabellar lobe. The pits of E_1 and I_1 are located close together in radial sulci at first, but beyond a point marked by R9 or R10 (the exact position on the holotype is not clear owing to imperfect preservation) the sulci increase in length (*exsag.*) owing to the development of a further outer row of pits, E_2, accompanied by a slight outward flexing of the cephalic margin. The large sulci, each containing three pits, continue as far as about R14 (exact position not quite clear) but then the two outermost rows continue, in smaller sulci, towards the genal angles whilst the inner row I_1 curves more strongly backwards to the posterior margin, the triangular area between it and the outer two rows being occupied by an irregular complex of about eleven pits. The pit count for the holotype cranidium is as follows : $E_1=22$; $E_2=11$; $I_1=20$; $I_2=19$; I_3 and $I_4=20$, with four large pits common to both rows. Well-defined, thin, concentric ridges, or lists as they were termed by Størmer (1930 : 12), occur between I_1 and I_2, and between I_2 and I_3. A less conspicuous ridge exists between I_3 and I_4 as far as R9, beyond which it diminishes and the two rows coalesce to form a single row of large pits beyond R17, there being room for three or four such pits before the margin is attained. There are eight or nine pits along the posterior margin. The ventral surface of the cephalic fringe is inadequately known, but is apparently of the type found in other species of *Tretaspis*, with a strongly developed girder, ornamented with raised terrace-lines, which extends on to the librigenal spines.

The thorax is not known.

The best-preserved pygidium, almost 9 mm. broad, is transversely semielliptical in plan, about four times as broad as long. The anterior margin, excluding the small articulating half-ring, is straight, ending in bluntly-pointed anterolateral angles. The posterior margin is uniformly curved, defined by a slightly raised marginal rim marking the upper limit of the steeply declined posterior border, which is ornamented by closely-grouped terrace-lines. The poorly differentiated axis is slightly raised above the side-lobes, from which it is separated by scarcely discernible axial furrows ; it occupies between one-third and one-quarter of the frontal breadth of the pygidium and narrows backwards only slightly. There are five axial rings, reducing in size from front to rear and separated from each other by ring furrows which become less impressed posteriorly, so that the fifth ring is separated from the marginal rim by only a faint groove. The first four axial rings are continued posterolaterally across the side-lobes as straight, raised ridges which just fail to attain the marginal rim. The ridges are smaller from first to fourth and progressively become directed more strongly backwards.

Horizon and localities. The first known specimens of the new subspecies came from a small exposure in the north bank of the River Onny, about 30 yards east of its junction with the stream leading south from Batch Gutter. At this point in the succession fairly well-preserved *Tretaspis ceriodes favus* was found occurring in a band of fossil fragments within grey mudstones containing a fauna of Actonian age, including *Calyptaulax*, *Chasmops*, *Remopleurides*, *Dolerorthis* and *Onniella*. The horizon is, in fact, topmost Actonian as the fossil band was seen to be overlain by rubbly mudstones containing *Onnia*? *cobboldi* (Bancroft), the index fossil of the lowest zone of the Onnian Stage. These higher mudstones also yielded a few examples of *Tretaspis ceriodes favus*, suggesting that the latter has a somewhat extended vertical range, but as all are fragmentary it is also possible that they have been derived from the underlying Actonian strata. No other post-Actonian specimens are known.

The subspecies has also been found in grey mudstones of Actonian age in the neighbourhood of Cardington, three miles east-north-east of Church Stretton.

The locality is in the west bank of the stream, 20 yards south of the Corn Mill, a quarter of a mile south-east of Cardington.

HOLOTYPE. B.M. In.54718 (Pl. 1, fig. 5 ; Pl. 2, figs. 1, 3–6).

PARATYPES. B.M. In.54719 (Pl. 2, fig. 2) ; In.54721 ; In.54722 ; In.54759 ; In.55656 ; In.55662.

DISCUSSION. The new subspecies is one of a group of forms of *Tretaspis* centred on *T. ceriodes* (Angelin) and all occurring in the southern Norwegian Stage 4bδ or its equivalent, including the Actonian and Onnian Stages of the Anglo-Welsh area.

The neotype cranidium of *T. ceriodes* (Størmer 1930, pl. 9, figs. 1a–d) is roughly two-thirds the size of the holotype of *T. ceriodes favus*, though with a similar number of pits in E_1, and there is no development of E_2. However, the upper lamella of a larger, damaged specimen figured by Størmer (1945, pl. 4, fig. 16) shows a few, perhaps four or five, large pits near the genal angle, suggesting a possible small development there of E_2. Again in the case of the neotype, I_3 and I_4 converge at about R12, that is to say farther forwards than in the Shropshire form. In the holotype of *T. ceriodes angelini* Størmer (1930, pl. 9, figs. 5a–c) the corresponding rows converge at about R8, and E_2 is developed from R10, or perhaps R9. The pygidium of *Tretaspis ceriodes favus* is similar to that of *T. ceriodes* but has five axial rings, one more than the small pygidium described by Størmer (1930 : 47, pl. 9, fig. 4). However, the pygidium of a larger specimen figured later by Størmer (1945, pl. 4, fig. 16) also possesses five axial rings.

Tretaspis ceriodes donsi Størmer (1945 : 405, pl. 1, fig. 8) was founded on a single, incomplete external mould of a small cranidium. On this specimen I_3 and I_4 converge at R7 or R8, and there appear to be six rows of pits in front of the glabella as stated by Størmer, indicating the presence there of E_2, though the state of preservation is not wholly satisfactory.

III. RELATIONSHIPS OF THE SOUTH SHROPSHIRE TRILOBITES

Trilobites are not known from the earliest Costonian strata in south Shropshire, but higher in the same stage their remains become progressively more abundant and in the topmost Costonian the trinucleid *Costonia* is of stratigraphical value. Although *Costonia* is a local genus, represented in south Shropshire by only two geographically separated species, it undoubtedly constitutes a development from the Anglo-Welsh genus *Marrolithus*, essentially a Llandeilo form but appearing as early as the Llanvirn Series and persisting in the Shelve Inlier as late as the Harnagian Stage (Spy Wood Grit). The Homalonotidae are well represented by the genera *Brongniartella* and *Platycoryphe* in the northern outcrops of the Costonian, though they are unknown in the south. Their derivation is problematical, but forms generally similar to *Brongniartella* have been described, as *Platycoryphe vulcani* (Murchison), from the Llanvirn Series of west Shropshire (Whittard 1961 : 164), whilst *Platycoryphe dentata* Dean (1961 : 340) may be related to the Bohemian *P. bohemica* (Barrande). Calymenid trilobites are, with few exceptions, almost ubiquitous throughout the type Caradoc succession. They make their appearance in the higher Costonian beds but, as in the case of the trinucleids, there is some geographical differentiation in species between the northern and southern outcrops, and *Flexicalymene* (*Reacalymene*) *pusulosa* (Shirley) is found only in the north ; this is the sole recorded occurrence of *Reacalymene* from this horizon, but the subgenus has been found as far afield as Baffin Island, in rocks of somewhat uncertain age (Whittington 1954). *Flexicalymene acantha* Bancroft, in the southern outcrops around Coston, is another trilobite suggesting a derivation from a Llandeilo species-group, and shows affinities with the earlier *F. cambrensis* Salter sp. (Dean 1962*a*). Of the other Costonian trilobites, *Proetidella* and an occasional asaphid, *Parabasilicus powisi* (Murchison), represent families which became more abundant in the succeeding Harnagian and Soudleyan Stages, but *Metopolichas*? sp., known from only two specimens, is a rare form of Llandeilo and Baltic affinities. These are the only lichids known in south Shropshire prior to the Actonian Stage, when members of the family became more abundant, though represented by a different genus, namely *Platylichas*.

In many respects the shelly fauna of the lowest Harnagian Stage is one of the most interesting in south Shropshire. Trinucleid trilobites are generally abundant in the earlier strata and, although *Reuscholithus* and *Smeathenia* are local genera, unknown elsewhere, *Broeggerolithus harnagensis* (Bancroft) and *Salterolithus praecursor* Dean represent the earliest known members of stratigraphically important genera, the origin of which is not clearly understood, and they may represent immigrant forms. *Broeggerolithus harnagensis* is close to a species found in the Derfel Limestone of the Bala district, associated with a fauna which has been shown to have strong Baltic affinities (Whittington & Williams 1955). In south Shropshire, although some of the early Harnagian brachiopods are of Baltic type, the only trilobite which could be described thus is *Acanthoparypha stubblefieldi* (Bancroft), but the genus is known also from the Middle Ordovician of North America. The genera *Kloucekia* and *Primaspis* indicate affinities with Bohemian faunas, and the former genus subsequently became a common constituent of Longvillian faunas in England and Wales.

In recent years Choubert and others (1956 : 394) have erected the name *Sokhretia* as a subgenus of *Kloucekia*, with type species *Dalmanites solitaria* Barrande 1852, for certain Ordovician trilobites from Morocco. As has been pointed out (Dean 1961 : 327) *D. solitaria* closely resembles the Anglo-Welsh species of *Kloucekia* (*Phacopidina*), of which subgenus *Sokhretia* is here regarded as a subjective synonym. The record is interesting, however, in extending the known geographical range of *Kloucekia*. The relatively sudden appearance of the so-called " exotic " trilobite elements may be correlated with what has been termed the " *Nemagraptus gracilis* Transgression ", widespread over much of England and Wales, ranging upwards in time, into the succeeding *Diplograptus multidens* Zone (Dean & Dineley 1961), and linking faunal regions which had previously been distinct from one another. On the other hand, certain trilobite groups in the Harnagian of south Shropshire represent a continuation of families which had already become established during the late Costonian ; they include the Asaphidae (*Parabasilicus*), Homalonotidae

(*Platycoryphe*) and Proetidae (*Proetidella*). The distribution of some of the Harnagian trilobites presents as yet unsolved problems, and *Parabasilicus* is known elsewhere only in South Korea and, perhaps, South America (Kobayashi 1935 : 475 ; Harrington & Leanza 1959 : 146), whilst the only extra-British record of *Salterolithus* is from Venezuela (Whittard 1959 : 89 ; Dean 1960 : 138). Of the Calymenidae, *Flexicalymene acantha* Bancroft continues from the Costonian, whereas *Gravicalymene praecox* (Bancroft) is of uncertain origin, appearing briefly in the basal Harnagian and then apparently leaving the district until Actonian times when closely similar forms re-entered south Shropshire, again a migration which may be connected with an important marine transgression, this time late in the *Dicranograptus clingani* Zone.

The remaining Harnagian trilobites in south Shropshire are poorly known and comprise only the trinucleids *Salterolithus caractaci* (Murchison) and *Broeggerolithus ulrichi* (Bancroft). The former belongs to a common Anglo-Welsh genus, but *B. ulrichi* is geographically restricted and has yet to be found outside the Welshpool district and, perhaps, the Onny Valley, though its existence at the latter place is doubtful.

In the Soudleyan and Lower Longvillian the general picture of the trilobite faunas is one of stability and uniformity, not only in south Shropshire but also over much of North Wales and northern England. Of the Trinucleidae, *Broeggerolithus broeggeri* (Bancroft) and *B. soudleyensis* (Bancroft) are well represented in both the Caradoc and Shelve districts and several North Welsh faunas, whilst in the Lower Longvillian, although *B. globiceps* (Bancroft) is apparently confined to Shropshire, the accompanying *B. nicholsoni* (Reed) becomes more abundant elsewhere, particularly in the argillaceous and mudstone environment of northern England (Melmerby Beds of the Cross Fell Inlier ; Drygill Shales near Carrock Fell) and the Pwllheli district of North Wales, and is of some stratigraphical value. With the exception of the uncommon and poorly-known "*Brongniartella*" *rudis* (M'Coy), a species in need of redescription (Dean 1961 : 355), the Homalonotidae are represented throughout south Shropshire and Wales by small species, such as *Brongniartella minor* (Salter), which form part of an indigenous group present in the Costonian. The same may also be said of the Asaphidae, represented by *Parabasilicus*?, and the Calymenidae, with *Flexicalymene planimarginata* (Reed), *F.* (*Reacalymene*) cf. *limba* (Shirley) and *F.* (*R.*) *horderleyensis* Dean. After apparently leaving the Anglo-Welsh area during the later Harnagian and the whole of the Soudleyan, *Kloucekia* returned in the Lower Longvillian, though as a different species, *K. apiculata* (M'Coy), and remained until late in the Upper Longvillian. The distribution of the pterygometopid genus *Chasmops* during the Lower Longvillian is interesting. Although members of the genus are not uncommon in North Wales, and occur also in the Melmerby district of the Cross Fell Inlier (Dean 1962 : 104), they have not been found in south Shropshire, though another species, *C. extensa* (Boeck), is abundant there later in the succession. The Illaenidae are almost unrepresented in the Anglo-Welsh area at this horizon, apart from a single record of *Stenopareia*? sp. at Cross Fell (Dean 1962 : 120).

The base of the Upper Longvillian Substage in south Shropshire is marked, at some points of the outcrop, by a small disconformity, followed in turn by a minor marine transgression which may, perhaps, explain certain curious features of the trilobite faunas. *Brongniartella bisulcata* (M'Coy), a relatively large species of the genus, appears in some abundance at the base of the Upper Longvillian, whilst higher in the same substage the Norwegian zonal index *Chasmops extensa* makes its début. That the incoming of such forms may be of more than local significance is suggested by the occurrence in North Wales of the Baltic genus *Estoniops* (*E. alifrons* M'Coy sp.), which also reached the Cross Fell Inlier (Dean 1962 : 100) though it has not been found in Shropshire. Certain of the other Upper Longvillian trilobites in south Shropshire showed little change from those of the Lower Longvillian. The trinucleid *Broeggerolithus longiceps* (Bancroft) was very close to *B. nicholsoni* (Reed), whilst *Kloucekia apiculata* persisted unchanged. *Atractopyge* in the higher beds of the Snowdon Volcanic Series of North Wales, and *Platylichas* in the Upper Melmerby Beds of the Cross Fell Inlier, are genera unknown from this horizon in Shropshire but represent groups which occurred both earlier, in the Derfel Limestone of Merionethshire, and later, in the Actonian, Onnian and Pusgillian Stages of Shropshire and Cross Fell.

The Marshbrookian trilobite fauna of south Shropshire is of generally conservative aspect, comprising in the main genera already present in the Upper Longvillian. *Brongniartella bisulcata* and *Chasmops extensa* are both abundant and of large individual size, whilst *Broeggerolithus transiens* (Bancroft) is of stratigraphical value and represents a development from the immediately preceding *B. nicholsoni* and *B. longiceps*. *Brongniartella bisulcata* and *Broeggerolithus* cf. *transiens* are known from the same horizon in the Cross Fell Inlier (Dean 1962 : 108, 82), though not from the Welsh area, perhaps the result of non-deposition of the relevant strata rather than actual absence of the species, but there is as yet no satisfactory explanation for the absence of *Chasmops extensa* from the Marshbrookian of Cross Fell, as the species is found in a variety of environments in Shropshire. Of the Calymenidae, only *Flexicalymene caractaci* (Salter) is of consequence in Shropshire. Though possibly deriving from earlier Anglo-Welsh species, *F. caractaci* bears perhaps the strongest resemblance to the Bohemian form *F. declinata* (Hawle & Corda), but as the latter is probably of Ashgill age (Dean 1962*a* : 220) it may have resulted from an emigration of the British species-group, which is unknown in Shropshire after the Marshbrookian. Although *Dindymene* was recorded by Bancroft (1949, text-fig. 39) from the Actonian of the Onny Valley in south Shropshire, his claim has not been substantiated, and the only Anglo-Welsh occurrences of the genus in the Caradoc Series are in the Upper Longvillian of North Wales and the Upper Longvillian and Marshbrookian of the Cross Fell Inlier (Dean 1962 : 89), though the genus was more common in Scottish, Bohemian and Polish faunas of Caradoc and Ashgill age (Kielan 1959). *Encrinurus* has a somewhat similar distribution in Shropshire and at Cross Fell. *Otarion* and *Proetidella*? have been found only rarely, and again represent old-established families in the Anglo-Welsh area, whilst an occasional *Primaspis* in the Shropshire Marshbrookian foreshadowed the relative abundance of the genus in the succeeding Actonian.

The Actonian and Onnian Stages may conveniently be considered together here as their trilobite faunas not only have certain elements in common, but also mark a profound change from those of preceding stages. Although the stratal succession in south Shropshire is continuous from the Marshbrookian to the Onnian, over much of the Anglo-Welsh area rocks of Marshbrookian, and even Longvillian, age are absent, the result of either erosion or non-deposition. At this point in the succession there then occurs the group of dark mudstones and shales known sometimes as the Nod Glas, which is widespread over large areas of North Wales. It marks a marine transgression late in the *Dicranograptus clingani* Zone, though occasionally extending upwards into the *Pleurograptus linearis* Zone ; by opening up new routes of communication with other faunal regions it must be considered largely responsible for the relatively sudden appearance of immigrant trilobite groups in the Shropshire Actonian. The family Trinucleidae, so important earlier in the succession, is only scantily represented by rare *Broeggerolithus transiens* (Bancroft) in the arenaceous facies of the middle Actonian, and by occasional *Tretaspis ceriodes favus* subsp. nov. (see p. 5) in the grey mudstones of the upper Actonian, the latter subspecies possibly extending upwards into the basal Onnian, at which point it overlaps with members of the genus *Onnia*, which become abundant and of zonal value. Of the Shropshire species of *Onnia*, *O. gracilis* (Bancroft) is somewhat difficult to place with reference to the other forms, exhibiting as it does affinities with the Bohemian *Onnia ornata* (Sternberg), and it may be that such a relationship could result from faunal migrations connected with the transgression of the Nod Glas. More conspicuous faunal links which may be correlated with the transgression are those with corresponding Scandinavian faunas. The Raphiophoridae are known for the first time in south Shropshire, with *Ampyxella edgelli* (Reed), a species virtually identical with *A. aculeata* (Angelin) from the Upper Chasmops Limestone, Etage 4bδ, of southern Norway, and *Lonchodomas pennatus* (La Touche) similarly exhibiting strong Scandinavian affinities. The calymenid genus *Onnicalymene* (Dean 1962 ; 1962*a*) appears in Shropshire in the Actonian, and ranges upwards through the Onnian in some abundance, comprising three species, *O. laticeps* (Bancroft), *O. salteri* (Bancroft) and *O. onniensis* (Shirley). The last-named occurs also in the Onnian of the Welshpool district and the Cross Fell Inlier, but in the latter district it ranges upwards through the black mudstones of the Pusgillian Stage. In both Norway and Sweden the genus is represented at the corresponding horizons, belonging to Etage 4bδ, by *Onnicalymene jemtlandica* (Thorslund). In Shropshire *Onnicalymene* replaces *Flexicalymene* sensu stricto as an important constituent of the fauna, but the relationship of the two genera is still not clear, and they may not represent a simple evolutionary series. The effects of the Nod Glas transgression may also be held responsible for the return of *Gravicalymene* in the Shropshire Actonian and, more rarely, Onnian after a long absence from the district, during which time there is as yet no evidence of its whereabouts. Of the Pterygometopidae, *Chasmops extensa* continued throughout the Actonian of Shropshire in even greater abundance than before, but disappeared early in the Onnian, whilst *Calyptaulax*, essentially an Actonian genus, is unknown later than the basal Onnian, where it is rare. The distribution of these two genera is unusual in that *Chasmops* is rare in the Cross Fell Inlier, known from only a few fragments in the Actonian and one in the Pusgillian (Dean 1962 : 104), whilst *Calyptaulax* appears uncommonly in the Onnian of the Dufton district, becoming increasingly abundant in the Pusgillian and eventually forming an important constituent of Ashgill shelly faunas in the Anglo-Welsh area. Similarly, *Dalmanitina*, best known from the Ashgill, has not been found in Shropshire but appeared at Cross Fell in the Pusgillian, though the genus has been described from part of the *Dicranograptus* Shales (?high Caradoc in age) of South Wales (Reed 1904). As stated earlier in this paper, the encrinurid genus *Atractopyge* is found in Welsh, Scottish and North American faunas of earlier age, but it makes only a brief appearance in the Shropshire Actonian. At Cross Fell, however, *Atractopyge* appears in the Onnian and, like *Calyptaulax*, increases in numbers in the Pusgillian. A somewhat similar distribution holds for *Platylichas laxatus* (M'Coy), abundant in the Actonian of Shropshire and almost identical with forms found in the Upper Chasmops Limestone, 4bδ, of southern Norway. The Illaenidae are not generally well represented in the Anglo-Welsh Caradoc Series, and their often fragmentary remains are not well documented, but most specimens have been found in the Actonian and Onnian of Shropshire where, again, the affinities appear to lie with Scandinavian species, for example *Illaenus fallax* Holm. The Swedish olenid *Triarthrus linnarssoni* Thorslund is represented in Shropshire (Dean 1962*a* : 241), one of a group of related Middle Ordovician species which is widely distributed through Scandinavia and North America but has not yet been proved in the Cross Fell district. The Odontopleuridae and Otarionidae occur infrequently in the Anglo-Welsh area, apart from the Actonian of south Shropshire. *Primaspis caractaci* (Salter) is moderately common in the arenaceous facies there and exhibits affinities with slightly earlier Bohemian and eastern North American species, so that it probably represents an immigrant group, though the genus has been found rarely in the Harnagian of Shropshire and the Longvillian of Cross Fell. In spite of the fact that remopleuridid remains have been recorded from practically all the Stages of the Caradoc in the Cross Fell Inlier, this family appears in Shropshire for the first time in the Actonian, where species of *Remopleurides* are close to contemporaneous Scandinavian forms, whilst in the Shropshire Onnian only *Remopleurella* is known, a genus found elsewhere in the Upper Chasmops Limestone of Norway (Dean 1962*a*: 250). At Cross Fell *Remopleurella* is unknown, but *Remopleurides* increased in numbers in the higher Pusgillian and eventually, like so many other trilobite groups, assumed even greater importance in the faunas of the Anglo-Welsh Ashgill Series. The thysanopeltid *Eobronteus*? sp., and the cheirurid *Pseudosphaerexochus* sp. represent rare elements in Anglo-Welsh Caradoc faunas, and their derivation is not clear.

IV. LIST OF THE KNOWN SOUTH SHROPSHIRE SPECIES

Costonian Stage

Brongniartella caradociana Dean 1961
Costonia elegans Dean 1960
Costonia ultima (Bancroft 1949)

Flexicalymene acantha Bancroft 1949
Flexicalymene (*Reacalymene*) *pusulosa* (Shirley 1936)
Metopolichas? sp.
Parabasilicus powisi (Murchison 1839)
Platycoryphe dentata Dean 1961
Proetidella fearnsidesi Bancroft 1949

Harnagian Stage

Acanthoparypha stubblefieldi (Bancroft 1949)
Broeggerolithus harnagensis (Bancroft 1929)
Broeggerolithus ulrichi (Bancroft 1949)
Broeggerolithus? sp.
Flexicalymene acantha Bancroft 1949
Gravicalymene praecox (Bancroft 1949)
Kloucekia (*Phacopidina*) *harnagensis* (Bancroft 1949)
Parabasilicus powisi (Murchison 1839)
Platycoryphe dentata Dean 1961
Primaspis harnagensis (Bancroft 1949)
Proetidella fearnsidesi Bancroft 1949
Reuscholithus reuschi Bancroft 1929
Salterolithus caractaci (Murchison 1839)
Salterolithus praecursor Dean 1960
Smeathenia smeathenensis (Bancroft 1949)

Soudleyan Stage

Broeggerolithus broeggeri (Bancroft 1929)
Broeggerolithus soudleyensis (Bancroft 1929)
Brongniartella minor (Salter 1852)
Brongniartella minor subcarinata Dean 1961
Flexicalymene (*Reacalymene*) cf. *limba* (Shirley 1936)
Parabasilicus powisi (Murchison 1839)
Proetidella cf. *fearnsidesi* Bancroft 1949

Longvillian Stage

Lower Longvillian Substage

Broeggerolithus globiceps (Bancroft)
Broeggerolithus nicholsoni (Reed 1910) [=*B. simplex* Dean 1960]
Brongniartella minor (Salter 1852)
Brongniartella sp.
Flexicalymene planimarginata (Reed 1906)
Flexicalymene (*Reacalymene*) *horderleyensis* Dean 1962
Kloucekia (*Phacopidina*) *apiculata* (M'Coy 1851)
Parabasilicus? sp.
Platycoryphe? sp.

Upper Longvillian Substage

Asaphid indet.
Broeggerolithus longiceps (Bancroft 1929)
Brongniartella bisulcata (M'Coy 1851)
Brongniartella edgelli (Salter 1865)—horizon of this species is uncertain
Chasmops extensa (Boeck 1837)
Flexicalymene cobboldi Dean 1962
Kloucekia (*Phacopidina*) *apiculata* (M'Coy 1851)

Marshbrookian Stage

Broeggerolithus transiens (Bancroft 1929)
Brongniartella bisculcata (M'Coy 1851)
Chasmops extensa (Boeck 1837)
Encrinurus sp. (? nov.)
Flexicalymene caractaci (Salter 1865)
Flexicalymene cobboldi Dean 1962
Otarion sp.
Primaspis caractaci (Salter 1857)
Proetidella? sp.

Actonian Stage

Ampyxella edgelli (Reed 1910)
Atractopyge sp.
Broeggerolithus cf. *transiens* (Bancroft 1929)
Brongniartella bisculcata (M'Coy 1851)?
Calyptaulax actonensis Dean 1961
Chasmops extensa (Boeck 1837)
Chasmops salopiensis Dean 1961
Gravicalymene cf. *praecox* (Bancroft 1949)
Illaenus sp.
Lonchodomas pennatus (La Touche 1884)
Onnicalymene laticeps (Bancroft 1949)
Onnicalymene salteri (Bancroft 1949)
Otarion sp.
Platylichas laxatus (M'Coy 1846)
Primaspis caractaci (Salter 1857)
Remopleurides latus Olin *onniensis* Dean 1962
Remopleurides warburgae Dean 1962
Tretaspis ceriodes (Angelin) *favus* subsp. nov.

Onnian Stage

Ampyxella edgelli (Reed 1910)
Calyptaulax actonensis Dean 1961
Chasmops extensa (Boeck 1837)
Eobronteus? sp.
Gravicalymene inflata Dean 1962

Gravicalymene cf. *praecox* (Bancroft 1949)
Illaenus cf. *fallax* Holm 1882
Lonchodomas pennatus (La Touche 1884)
Onnia? cobboldi (Bancroft 1929)
Onnia gracilis (Bancroft 1929)
Onnia superba (Bancroft 1929)
Onnia aff. *superba* (Bancroft 1929)
Onnicalymene onniensis (Shirley 1936)
Platylichas laxatus (M'Coy 1846)
Pseudosphaerexochus sp.
Remopleurella burmeisteri (Bancroft 1949)
Tretaspis ceriodes (Angelin) *favus* subsp. nov.
Triarthrus cf. *linnarssoni* Thorlsund 1940

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